

This Page Is Inserted by IFW Operations  
and is not a part of the Official Record

## **BEST AVAILABLE IMAGES**

Defective images within this document are accurate representations of the original documents submitted by the applicant.

Defects in the images may include (but are not limited to):

- BLACK BORDERS
- TEXT CUT OFF AT TOP, BOTTOM OR SIDES
- FADED TEXT
- ILLEGIBLE TEXT
- SKEWED/SLANTED IMAGES
- COLORED PHOTOS
- BLACK OR VERY BLACK AND WHITE DARK PHOTOS
- GRAY SCALE DOCUMENTS

**IMAGES ARE BEST AVAILABLE COPY.**

**As rescanning documents *will not* correct images,  
please do not report the images to the  
Image Problems Mailbox.**

THIS PAGE BLANK (USPTO)



Europäisches Patentamt

European Patent Office

Office européen des brevets

(19)



(11)

EP 0 969 699 A1

(12)

## EUROPEAN PATENT APPLICATION

(43) Date of publication:  
05.01.2000 Bulletin 2000/01

(51) Int. Cl.<sup>7</sup>: H05B 33/02, H05B 33/12

(21) Application number: 99112509.7

(22) Date of filing: 01.07.1999

(84) Designated Contracting States:

AT BE CH CY DE DK ES FI FR GB GR IE IT LI LU  
MC NL PT SE

Designated Extension States:

AL LT LV MK RO SI

(30) Priority: 02.07.1998 IT TO980580

(71) Applicant:

C.R.F. Societa' Consortile per Azioni  
10043 Orbassano (Torino) (IT)

(72) Inventors:

• Perlo, Piero,  
c/o C.R.F. Soc. Consortile per A.  
10043 Orbassano (Torino) (IT)

• Repetto Piermario

c/o C.R.F. Soc. Consortile per A  
10043 Orbassano (Torino) (IT)

• Bigliati, Claudia,

C.R.F. Soc. Consortile per A.  
10043 Orbassano (Torino) (IT)

• Farina, Silvia,

C.R.F. Soc. Consortile per Azioni  
10043 Orbassano (Torino) (IT)

• Negri, Alessandro,

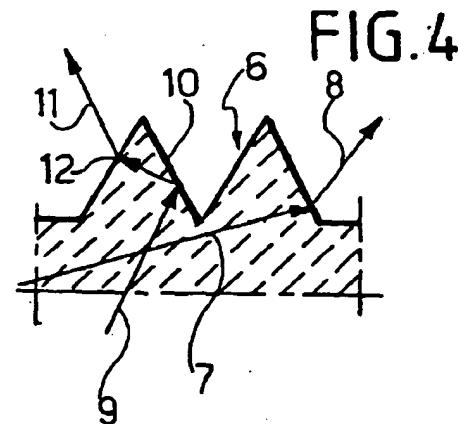
C.R.F. Soc. Consortile per A.  
10043 Orbassano (Torino) (IT)

(74) Representative:

Notaro, Giancarlo et al  
c/o Buzzi, Notaro & Antonielli d'Oulx srl,  
Corso Flume 6  
10133 Torino (IT)

(54) Light-emitting device based on an electroluminescent organic material, having a shaped outer interface

(57) A light emitting device based on an organic material comprises at least one emitting source including at least one layer of electroluminescent organic material (1, 2) located over a layer of transparent metal material, which is used as an electrode and a substrate transparent plate, for example made of glass or plastic material. The substrate plate (5) has one or both its surfaces (5a) shaped with a plurality of microprojections (6) arranged in a matrix each having a height/width ratio (H/L) not lower than 1.



EP 0 969 699 A1

## Description

[0001] The present invention relates to light-emitting devices based on an organic luminescent material of the so called LEP (Light-Emitting Polymers) type or OLED (Organic Light-Emitting Devices) type. Devices of this type have been described for example in "High-External Quantum-Efficiency Organic Light-Emitting Devices", Garbuзов et al., OPTICS LETTERS, vol. 22, n. 6, March 15 1997.

[0002] The devices of the above indicated type (see figure 1 of the annexed drawings) commonly have a first layer 1 of electroluminescent material, such as Alq<sub>3</sub>, for example having a thickness of 80nm, and a second layer 2 of the same thickness made of a material such as N,N'-diphenyl-N,N'-bis(3-methylphenyl)-1,1'biphenyl-4,4'diamine (TPD). At the back of layer 1 there is applied an electrode 3, whereas on the front the layer 2 is covered by a transparent plate 4 acting as electrode, typically made of ITO (Indium Tin Oxide), having a thickness of about 150nm. The above described structure is then covered by a substrate plate 5, such as of glass, having a thickness for example of 1.1nm.

[0003] The light-emitting devices of the above indicated type have a very high efficiency, but have the drawback that only a small portion of the generated light (generally in the order of 20-30% at most) is able to get out of the device, the larger remaining portion being instead wasted through a sequence of reflections inside the transparent plates, due to a wave guide effect. The light flow at the output is generally proportional to the current supplied to the two electrodes of the device, so that one can try to overcome the above mentioned drawback by increasing the current being supplied. However, in this manner the average life of the device is substantially reduced.

[0004] The above indicated publication discloses a tentative solution to the above mentioned problem in which the structure of the device has a substrate shaped so as to define a plurality of emitting sources located at apices of pyramids or cones having reflective lateral surfaces which reflect the rays emitted by the source at a large divergence angle so as to cause these rays to get out from the front of the device, thus avoiding the wave guide effect which has been described above. However, the solution has the drawback of having a relatively complicated and costly structure.

[0005] The object of the present invention is that of providing a simple and efficient solution to the problem which has been indicated in the foregoing.

[0006] In view of achieving this object, the invention provides a light-emitting device based on an organic material, comprising at least one emitting source including at least one layer of electroluminescent organic material, a layer of transparent metal material acting as electrode located over the layer of electroluminescent material and a transparent substrate plate, for example made of glass or plastic material, located over the trans-

parent electrode, as well as an electrode applied at the back of the layer of electroluminescent material and means for applying an electric voltage to said electrodes, so as to cause the emission of light from the layer of electroluminescent material, characterized in that at least one of the two surfaces of said substrate plate is shaped with a plurality of micro-projections.

[0007] According to a further preferred feature, also one or more of the other layers of the device have one or both of their surfaces similarly shaped.

[0008] In a preferred embodiment, said micro-projections are arranged according to a matrix. Each micro-projection may have a conical or pyramidal or prismatic shape and has a height/transverse dimension ratio not lower than 1: The height of the projections is for example chosen between 0.01mm and 0.1mm.

[0009] Due to the above indicated features, the light rays which are emitted by the device at a large divergence angle meet the surfaces of the micro-projections at an angle which is lower than that which would occur if the surface of the glass plate were planar, so that these rays are not reflected inside the glass plate, but rather are transmitted to the outside. Instead, as far as the rays having a small incidence angle are concerned, they are reflected a first time on the surface of a micro-projection to be then recovered and directed to the outside at the other surface of the micro-projection which is subsequently met.

[0010] Due to the above indicated features, the quantity of light which is transmitted to the outside by the device is very relevant and may arrive to be in the order of 80% of the total emitted light.

[0011] According to a further preferred feature, two series of uniformly distributed micro-projections can be provided, the projections of the first series having a height substantially greater than the projections of the second series, in order to obtain the best characteristics for the emitted beam.

[0012] Further features and advantages of the invention will become apparent from the following description with reference to the annexed drawings, given purely by way of non limiting example, in which:

figure 1, which has been already described, shows a light-emitting device according to the prior art,  
 figure 2, shows a detail of figure 1 at an enlarged scale, modified according to the teaching of the present invention,  
 figure 3 shows a further detail of the portion shown in figure 2,  
 figure 4 also shows the detail of figure 2 and the principle which is at the base of the invention,  
 figure 5 shows a variant of figure 2 and  
 figures 6, 7 diagrammatically show a further variant.

[0013] With reference to figure 2, according to the invention, the surface of outer interface 5a of the substrate plate 5 is shaped with a plurality of micro-projec-

tions 6 having a conical or pyramidal shape, arranged in a matrix. Alternatively, the micro-projections can be located on the opposite face or also on both faces. The plate 5 can also be of plastic (rigid or flexible) material, such as PET or OCLAR. In the case of use of a porous plastic material, a protective layer can be applied, such as of silicon oxide, in order to isolate the device from the outside environment. In the case that both faces of plate 5 are shaped with micro-projections, the two profiles of these faces can be out-of-phase relative to each other in order to render a further parameter available in order to improve the quantity of extracted light. The micro-projections 6 (figure 3) have a H/width L ratio (H/L) not lower than 1. Due to this feature, the light rays emitted by the source at a large incidence angle (such as the ray designated by 7 in figure 4) are not reflected inside the plate 5 (as it would instead occur if they met a planar surface) because they encounter the lateral surface of the micro-projections at a small incidence angle. The ray 7 is therefore transmitted to the outside in form of a ray 8. The rays of the type designated by 9 in figure 4, which are emitted by the source at a small incidence angle are reflected inside the plate after that they have met the lateral surface of a micro-projection at 10 at a first time, but are then recovered and transmitted to the outside in form of a ray 11 after that they have met the other lateral surface of the micro-projection at 12 at a second time. Therefore, the quantity of light emitted to the outside by the device is substantially increased with respect to what happens in the case of the device shown in figure 1 having a planar outer interface 5a.

[0014] In a preferred embodiment, the height of the pyramidal micro-projection is in the order of 0.01-0.1mm, for example 0.02mm and the horizontal dimension is in the order of 0.015 micrometers.

[0015] Figure 6 shows a further embodiment which has two series of microprojections 6, 60 which are alternated to each other and uniformly distributed in a matrix, with microprojections 60 of the second series having a substantially lower height than the height of microprojections 6 of the first series. By this arrangement, a light beam having best characteristics can be obtained at the output.

[0016] Figure 5 shows a variant in which the microprojections (designated by 6) have a binary shape with a subwavelength structure under wavelength. In this case in the preferred embodiment the microprojections have a height between 0.15 and 0.25 micrometer and a period of 0.5-0.7 micrometers with a filling factor of 0.5.

[0017] According to a further preferred feature, also one or more of the other layers of the device, apart from layer 5, have one or both surfaces shaped in a similar way (see figure 7).

[0018] Naturally, while the principle of the invention remains the same, the details of construction and the embodiments may widely vary with respect to what has been described and illustrated purely by way of example, without departing from the scope of the present

invention.

## Claims

5. 1. Light emitting device based on an organic material, comprising at least one emitting source, including at least one layer (1, 2) of electroluminescent organic material, one layer (4) of transparent metal material, which is used as an electrode, located over the layer of electroluminescent material (1, 2), a transparent substrate plate (5), located over the transparent electrode (4), an electrode (3) applied at the back of the layer of electroluminescent material (1, 2) and means for applying an electric voltage to said electrodes, so as to cause the emission of light by the layer of electroluminescent material, characterized in that at least one of the two surfaces (5a) of said substrate plate is shaped with a plurality of microprojections (6) arranged in a matrix.
10. 2. Device according to claim 1, characterized in that said microprojections (6) have a conical or pyramidal or prismatic shape.
15. 3. Device according to claim 1, characterized in that each microprojection (6) has a height/width ratio (H/L) not lower than 1.
20. 4. Device according to claim 1, characterized in that the microprojections are of subwavelength binary type, preferably with a height between 0.15 and 0.25 micrometers, period of 0.5 to 0.7 micrometers and filling factor of 0.5, said values being chosen as a function of the emitted wavelength.
25. 5. Device according to claim 1, characterized in that there are provided two series of microprojections (6, 60), the projections of the first series (6) having a height which is substantially greater than the height of the microprojections of the second series (60).
30. 6. Device according to claim 1, characterized in that said substrate plate (5) is made of glass.
35. 7. Device according to claim 1, characterized in that said substrate plate (5) is of plastic (rigid or flexible) material, such as PET, preferably provided with a protective layer, such as silicon oxide.
40. 8. Device according to claim 1, characterized in that apart from said substrate plate (5), also further layers of said device have one or both faces shaped as said substrate plate (5).

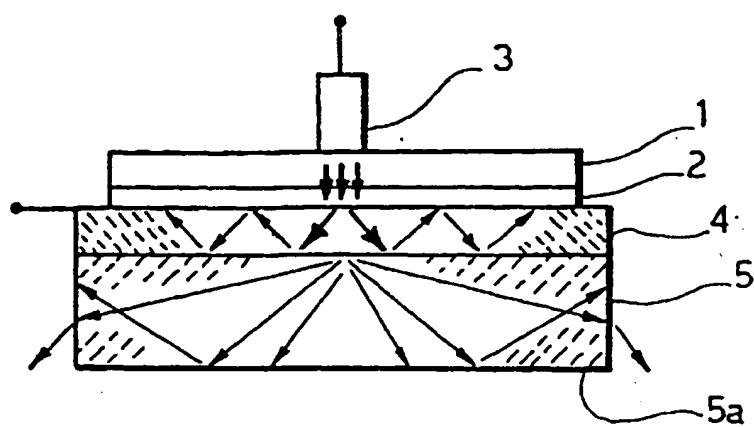


FIG. 1

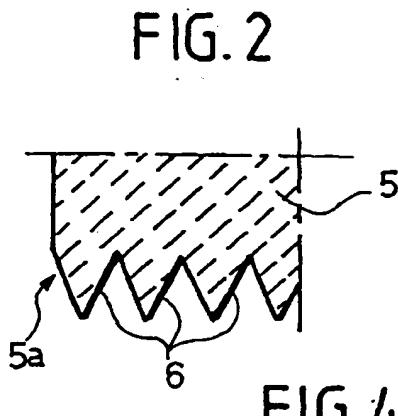


FIG. 2

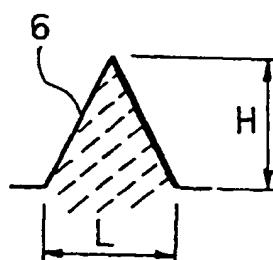


FIG. 3

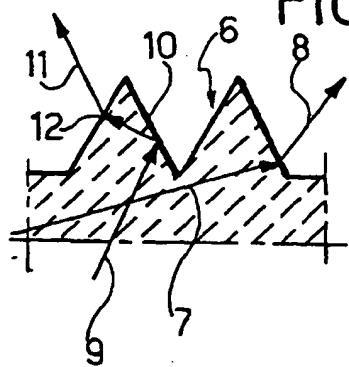


FIG. 4

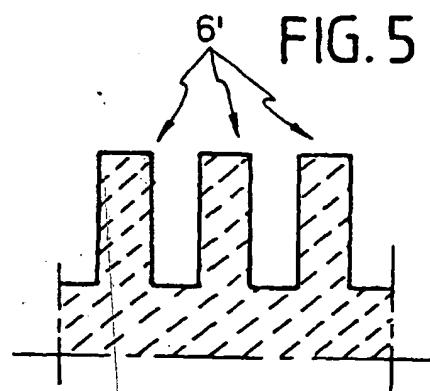


FIG. 5

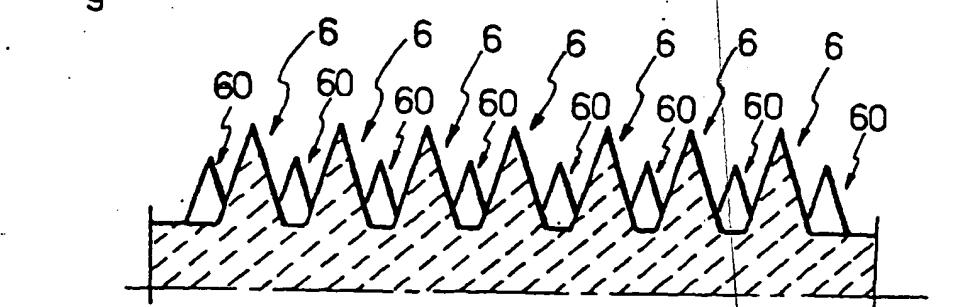
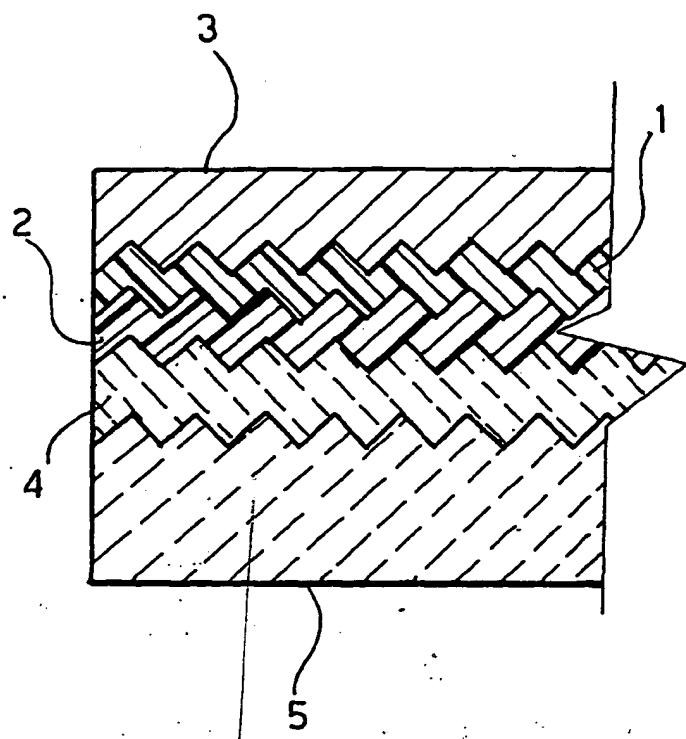


FIG. 6

FIG. 7





European Patent  
Office

## EUROPEAN SEARCH REPORT

Application Number  
EP 99 11 2509

## DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.7)
X	WO 92 14173 A (AMERICAN INGENUITY INC) 20 August 1992 (1992-08-20) * page 16, line 20 - page 18; figure 4 *	1-3,7	H05B33/02 H05B33/12
X,P	WO 98 57525 A (ABE HIDETOSHI ;ARAKI YOSHINORI (JP); MINNESOTA MINING & MFG (US)) 17 December 1998 (1998-12-17) * the whole document *	1,2,7	
X	DATABASE WPI Section PQ, Week 9718 Derwent Publications Ltd., London, GB; Class P81, AN 97-198425 XP002116335 & JP 09 054171 A (CITIZEN WATCH CO LTD), 25 February 1997 (1997-02-25) * abstract *	1,2,7	
X	PATENT ABSTRACTS OF JAPAN vol. 097, no. 009, 30 September 1997 (1997-09-30) & JP 09 115667 A (SONY CORP), 2 May 1997 (1997-05-02) * abstract *	1,2,8	TECHNICAL FIELDS SEARCHED (Int.Cl.7)
X	PATENT ABSTRACTS OF JAPAN vol. 098, no. 004, 31 March 1998 (1998-03-31) & JP 09 326297 A (CASIO COMPUT CO LTD), 16 December 1997 (1997-12-16) * abstract *	1,2	H05B
		-/-	
The present search report has been drawn up for all claims.			
1	Place of search THE HAGUE	Date of completion of the search 23 September 1999	Examiner Drouot, M-C
CATEGORY OF CITED DOCUMENTS		T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document	
X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document			



European Patent  
Office

## EUROPEAN SEARCH REPORT

Application Number  
EP 99 11 2509

DOCUMENTS CONSIDERED TO BE RELEVANT			CLASSIFICATION OF THE APPLICATION (Int.Cl.7)
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	
A	<p>DATABASE WPI Section PQ, Week 9713 Derwent Publications Ltd., London, GB; Class P81, AN 97-136304 XP002116336 &amp; JP 09 015596 A (SEIKOSHA KK), 17 January 1997 (1997-01-17) * abstract *</p> <p>---</p> <p>WO 96 36201 A (TIMEX CORP) 14 November 1996 (1996-11-14) * the whole document *</p> <p>---</p>	1,2	
		1	
			TECHNICAL FIELDS SEARCHED (Int.Cl.7)
<p>The present search report has been drawn up for all claims</p>			
Place of search	Date of completion of the search	Examiner	
THE HAGUE	23 September 1999	Drouot, M-C	
CATEGORY OF CITED DOCUMENTS		<p>T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application C : document cited for other reasons &amp; : member of the same patent family, corresponding document</p>	
<p>X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document</p>			

ANNEX TO THE EUROPEAN SEARCH REPORT  
ON EUROPEAN PATENT APPLICATION NO.

EP 99 11 2509

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

23-09-1999

Patent document cited in search report		Publication date	Patent family member(s)		Publication date
WO 9214173	A	20-08-1992	AU	1367492 A	07-09-1992
			EP	0570504 A	24-11-1993
			US	5237448 A	17-08-1993
			US	5243457 A	07-09-1993
WO 9857525	A	17-12-1998	JP	11008063 A	12-01-1999
			AU	7809198 A	30-12-1998
JP 9054171	A	25-02-1997	NONE		
JP 09115667	A	02-05-1997	NONE		
JP 09326297	A	16-12-1997	NONE		
JP 9015596	A	17-01-1997	JP	2791355 B	27-08-1998
WO 9636201	A	14-11-1996	US	5620348 A	15-04-1997
			AU	5738696 A	29-11-1996
			CA	2220943 A	14-11-1996
			EP	0827679 A	11-03-1998